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Evaluation of Urea and NPKS Fertilizer and Seed Rates for Wheat Crop at Selected FTC Sites of East Gojam Zone, Ethiopia

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Abstract
To meet the food demand and the need of emerging agro-industries in the country, increasing the production and productivity of wheat with appropriate soil management practice is important. Therefore, field study was conducted with the objectives of evaluating application of Urea and NPKS fertilizer and seed rates for wheat crop at selected FTC sites of East Gojam Zone during the 2015/2016 cropping season. Kekeba wheat variety was used in the research. The research consisted of six treatments, i.e. combined application of three rates (Package, Innovation and Framers' practice) of urea and NPKS fertilizer and two seed rates (recommended and farmers practice) were arranged in RCBD with three replications. The data were subjected to two-way ANOVA using SAS program [version 9] and comparisons of means were performed using the LSD. The results of ANOVA showed that except the number of spike and number of grains per spike, all other yield and yield attributes were significant affected by Urea and NPKS fertilizers and seed rates application. the longest plant height and spike length, and the maximum total above ground biomass and straw yield were recorded from the application of 322 kg Urea + 200kg NPKS +200kg seed/ha. Even though it was non-significant, much number of spikes was counted from the application of 322 kg Urea + 200kg NPKS +200kg seed/ha at Enereta site. A lot of fertile tillers were counted from the applications of 300 kg Urea + 100kg NPKS +200kg seed/ha at the two sites. The less number of fertile tillers were counted from the use of 100 kg Urea + 200kg NPKS +200kg seed/ha and 322 kg Urea + 200kg NPKS +100kg seed/ha at Campus and Enereta FTC respectively. The highest grain yields were measured by the application of 300 kg Urea + 100kg NPKS +100kg and of 322 kg Urea + 200kg NPKS +200kg at Campus and at Enereta FTC respectively. Generally at Enereta FTC, the optimum amount of urea, NPKS and seed rate can be estimated as 300/322 kg Urea, 100kg /200kg NPKS and 200/200 kg seed respectively. At campus site the optimum amount of urea, NPKS and seed rate can be estimated as 300 /300 kg Urea, 100/100kg NPKS and 100/200 kg seed respectively. However, their economic rates of fertilizer and seed applications would have to be assessed to achieve sustainable crop yields. Unlike to soil of the campus, soils of Enereta FTC was highly depleted so that optimum plant growth and better production can be obtained from higher dose of urea, and NPKS, but adequate soil analysis must be made for both sites. In general, management activities for the crop and these soils; should be practiced, and the strategies for which should be applied according to either the package or Innovative fertilizer use practice.
Keywords: Innovative fertilizer, blended fertilizer, Urea, Kekeba variety

1. INTRODUCTION

Ethiopia is the second most populous country in Africa with a population of 73,750,932 (CSA, 2010). Agriculture is the leading sector in the country's economy that accounts for about 45% of the gross domestic product (GDP), employs about 80% of the labor force and generates about 80% of the export earnings (CSA, 2009). As the case with many other developing countries, cereals constitute staple food and provide the major portion of energy and protein consumed by the population. In Ethiopia many cereals are also the most important commodities supplied to local markets, and hence important sources of cash income to millions of farming households.

In Ethiopia, Wheat is the major cereal crop grown in the highlands with altitudes of 1500 to 3200 m.a s.l. (white et al., 2001). The country is the second largest producer of wheat in sub-Saharan Africa following South Africa. CSA estimates indicate that since 2006, the area used for wheat production has shown an average growth of 2.63% per year, while yield and total production have shown average annual growth rates of 5.25% and 7.8% respectively making it one of the most important cereal crops in the country. In absolute terms, total national wheat production is expected to show a 64% growth in 2013/14 from what it was in 2006. Still, although Ethiopia has seen relatively steady improvement in wheat production in recent years, particularly in per hectare production, demand continues to outpace supply, and the production growth has been a fraction of what it could be with more focused effort and attention.

Wheat's national average yield can be easily doubled simply by improving agronomic practices, providing improved access to technologies. To meet the food demand and the need of emerging agro-industries in the country, increasing the production and productivity of wheat with appropriate soil management practice is important.

In the Ethiopian highlands, soil loss due to water erosion is about 1493 million tons per annum as estimated by Hurni (1993). Of this, nearly half is estimated to come from the cultivated fields, which account for only about 13% of the country's total area. These losses will inevitably cause yield decreases unless appropriate measures are taken. Although much of the highlands have high potential for food production because of favorable seasonal precipitation, many of the soils are deficient in plant nutrients.

In addition, Ethiopia has soil types with inherent characteristics which can be problematic for crop production and which need special management (IFPI, 2010). Soil degradation and nutrient depletion in the country have gradually increased in area and magnitude and have become serious threats to agricultural productivity (Fasil and Charles, 2009).

Similarly, soils in the highlands of Ethiopia usually have low levels of essential plant nutrients and organic matter (OM) content, especially low available Nitrogen (N) and Phosphorus (P) has been demonstrated to be major constraint for cereal production and therefore application of fertilizers on these soils play a major role in increasing food production to meet the demands of the growing population (Tekalign *et al*., 1988).

Inorganic fertilizers are a normal requirement for high crop yields. It is estimated that 30-50% of today's crop production in the world comes directly from the use of inorganic fertilizers. Use of the correct type, rate, time and method of application of fertilizers is important for raising production and avoiding damage to the environment. Furthermore, Inorganic fertilizers can quickly replenish lost plant nutrients.

However, despite several years of agronomic research on the response of specific food crops to various types of fertilizers, over-generalized and rigid recommendations on their use continue to be made (Gachene and Gathiru, 2003). Such a blanket recommendation does not do justice to the differences in agro-ecology, indigenous soil nutrient supplies and crop specifications (Asefa, 2008). The blanket fertilizer recommendation may be in excess of or less than the optimum requirement for crop growth and development. Therefore, the best types and amounts of fertilizer to use for a particular crop in a given area should be decided.

Plant density is also major factor determining the ability of the crop to capture resources and generate yield. It can be developed by using a suitable seeding rate. Maximum genetic potential of high yielding Wheat varieties cannot be harvested without ensuring proper seeding rate. As the plant density increases, the competition for resources especially for nitrogen also increases, which badly affect the ultimate grain yield (Nazir et al., 2000). There is no considerable work done in the study area to evaluate for seed rate and NP fertilizer response of wheat crop. Use of a given high yielding Wheat genotype accompanied with improved production technology packages like optimum NP fertilizations with optimum planting density could markedly increase productivity per a given hectare. Therefore, taking these problems into account this research was initiated with the following objectives.

- To evaluate the effects of applied Urea and NPKS rates with different seed rates on wheat crop at selected FTC sites of East Gojam Zone, Ethiopia
- To determine the optimum Urea and NPKS fertilization and the optimum seed rates for wheat crop on the soils of East Gojam Zone

2. MATERIALS AND METHODS

2.1 Description of the Study Area

Field trials were conducted in North Western part of Ethiopia, East Gojam Zone in 2015/2016 cropping season across two FTC sites in Gozamen district (Debre Markos University research site and Enerata kebele FTC). East Gojam Zone is situated in Amhara Regional State at Debre Markos town. Debre Markos is geographically located 299 km Northwest of Addis Abeba at about 10° 18' 10" N latitude and 37° 44' 53" E longitude at an altitude of 2450 meter above sea level (m.a.s.l). The mean maximum and minimum temperature are 10.6 and 22.3^{0}C, respectively and the mean maximum and minimum relative humidity are and respectively. The mean annual rainfall of the area is 1100mm.

2.2. Experimental Treatments and Design

The field experiment comprised of six treatments. namely T1 (322 kg Urea + 200kg NPKS +100kg seed/ha), T2 (322 kg Urea + 200kg NPKS +200kg seed/ha), T3 (300 kg Urea + 100kg NPKS +100kg seed/ha), T4 (300 kg Urea + 100kg NPKS +200kg seed/ha), T5(100 kg Urea + 200kg NPKS +100kg seed/ha) and T6(100 kg Urea + 200kg NPKS +200kg seed/ha). The treatments were arranged in randomized complete block design (RCBD) with three replications. A total of eighteen treatments were used in the experiment.

2.3. Experimental Procedures and Field Management

The experimental site were plowed thoroughly twice by oxen and leveled by human labor then divided into sub-plots in accordance with the treatments. The fields were leveled uniformly for proficient distribution of fertilizer and uniform infiltration of water from rainfall. The size of each plot was 4 m x 3 m (12 m^2) each containing nine rows and the middle rows were used for data collection. The space between rows was 30 cm. The space between plots was 1 m and the space between the blocks was 2 m. The wheat variety named kekeba was used. the variety was obtained from Adet Agricultural Research Center. At planting, wheat seeds were seeded by hand drilling with combined application of urea and NPKS fertilizers. The urea fertilizer was applied in to two splits. Full dose of NPKS and one-third dose of urea were applied at the time of sowing. After 35-40 days of the first application, the second remaining two-third dose of urea was applied after the first weeding. Furthermore, all standard local cultural practices such as weeding have been periodically applied during the different growth stages of the crop. The plant growth on the farmers' fields was regularly supervised, and inspected.

2.4. Data Collected

Plant height (cm), number of fertile tillers per m^2, number of spike per m^2, number of grains per spike, spike length (cm), grain yield, straw yield, and total above ground biomass yield were collected.

Plant height was measured from randomly sampled 10 plants per plot at physiological maturity, whereas the number of fertile tillers and the number of spikes per $1.6m^2$ (40cmx40cm) were determined at the late tillering stage and at maturity, respectively. The number of grains per spike was recorded from randomly sampled five spikes taken from the net plot area. Similarly the spike length was measured from randomly sampled 10 spikes taken from the net plot area.

Grain and straw yields were determined by harvesting the entire net plot of 12 m^2 and converted into kilogram per hectare. The yield was measured after leaving the harvested plants in open air for about 10 days so that they attained constant weight. Similarly, total above ground biomass yield was determined by weighing after complete sun drying at harvest. Grain yield was measured by threshing the plants at harvest from the net plot area and straw yield will be determined as the difference between the total above ground biomass (straw plus grain) and the grain yield of the respective treatments.

2.5. Statistical Analysis

The yield and other crop data were subjected to analysis of variance (ANOVA) appropriate to randomized complete block design (RCBD) using satirical analyses software (SAS) program [SAS Institute, version 9]. Comparisons of means were performed using the least significant difference (LSD).

3. RESULTS AND DISCUSSIONS

3.1. Growth Response to NP Fertilizers and Seed Rates Application

3.1.1. Plant height

The results of analysis of variance indicate that NPKS fertilizers and seed rates application was significant on plant height at both experimental fields (Table 1). Use of 322 kg Urea + 200kg NPKS +200kg seed/ha resulted the longest plant height followed by the application of 300 kg Urea + 100kg NPKS +200kg seed/ha at both Debre Markos University research site and Enerata kebele FTC (Table 1). The shortest plant height was measured from the application of 100 kg Urea + 200kg NPKS +100kg seed/ha and300 kg Urea + 100kg NPKS +100kg seed/ha at both sites (Table 1).

Table 1. Evaluation of urea and blended fertilizer and seed rates on plant height and spike length at selected FTC sites of East Gojam Zone

Treatments	Debre Markos University research site		Enereta kebele FTC	
	Plant Height (cm)	Spike Length (cm)	Plant Height (cm)	Spike Length (cm)
1	80.967 ^{cd}	9.4667^{ba}	68.447^{ab}	8.6833 ^{a}
2	95.133 ^{a}	9.6000^{a}	72.420 ^{a}	8.3167 ^{ab}
3	75.133 ^{ed}	9.8667^{a}	62.347 ^{C}	8.2667 ^{ab}
4	87.733 ^{b}	8.9000^{c}	68.780 ^{ab}	7.9333 ^{b}
5	72.667 ^{e}	9.5833^{a}	66.413 ^{bC}	8.2000 ^{ab}
6	83.967 ^{cb}	8.9900^{bc}	73.723 ^{a}	8.2333 ^{ab}
LSD (0.05)	0.615	0.5163	5.8803	0.5386
CV	4.185373	3.086881	4.705686	3.578708

Means followed by the same letter in a column are not significantly different at P = 0.05; NS = No significance, CV = Coefficient of variation, LSD = Least significant difference. **T: 1= (**322 kg Urea + 200kg NPKS +100kg seed/ha**), T: 2= (**322 kg Urea + 200kg NPKS +200kg seed/ha**), T: 3= (**300 kg Urea + 100kg NPKS +100kg seed/ha**), T: 4= (**300 kg Urea + 100kg NPKS +200kg seed/ha**), T: 5= (**100 kg Urea + 200kg NPKS +100kg seed/ha**), T: 6= (**100 kg Urea + 200kg NPKS +200kg seed/ha**)**

3.1.2. Spike Length

The results of analysis of variance indicate that NPKS fertilizers and seed rates application was less significant on spike length at both sites (Table 1). At Debre Markos University research site the longest spike length was measured from the application of 300 kg Urea + 100kg NPKS +100kg seed/ha though it was statically similar with the applications of 322 kg Urea + 200kg NPKS +200kg seed/ha and 100 kg Urea + 200kg NPKS +100kg seed/ha (Table 1).. But the longest spike length at Enereta Kebele FTC was measured from the application of

322 kg Urea + 200kg NPKS +100kg seed/ha (Table 1).. The shorter spike lengths were measured from the applications of 300 kg Urea + 100kg NPKS +200kg seed/ha and 100 kg Urea + 200kg NPKS +200kg seed/ha at both sites (Table 1)..

3.2. Yield and Yield Attributes Response to NP Fertilizers and Seed Rates Application

3.2.1. Number of Grains per Spike

The results of analysis of variance indicate that NPKS fertilizers and seed rates application was non- significant effect on number of grains per spike at both sites (Table 2). Even though it was non- significant, better number of grains per spike was counted from the application of 100 kg Urea + 200kg NPKS +200kg seed/ha and 322 kg Urea + 200kg NPKS +100kg seed/ha at both sites(Table 2). .

Table 2. Evaluation of urea and blended fertilizer and seed rates on number of grains per spike and number of spike at selected FTC sites of East Gojam Zone

Treatments	Debre Markos University research site		Enereta kebele FTC	
	Number of Grains per Spike	Number of Spike	Number of Grains per Spike	Number of Spike
1	58.400 [a]	100.00 [ba]	54.800 [a]	52.67 [bc]
2	53.600 [a]	101.00 [ba]	52.333 [ab]	86.00 [a]
3	58.600 [a]	119.33 [a]	41.733 [b]	42.33 [c]
4	54.467 [a]	105.67 [ba]	49.067 [ab]	74.00 [ab]
5	62.533 [a]	90.67 [b]	51.600 [ab]	62.00 [ab]
6	54.733 [a]	100.33 [ba]	48.800 [ab]	70.33 [ab]
LSD (0.05)	9.8291	27.071	11.114	25.92
CV	9.683710	14.79768	12.28664	22.07001

Means followed by the same letter in a column are not significantly different at P = 0.05; NS = No significance, CV = Coefficient of variation, LSD = Least significant difference. **T: 1= (**322 kg Urea + 200kg NPKS +100kg seed/ha**), T: 2= (**322 kg Urea + 200kg NPKS +200kg seed/ha**), T: 3= (**300 kg Urea + 100kg NPKS +100kg seed/ha**), T: 4= (**300 kg Urea + 100kg NPKS +200kg seed/ha**), T: 5= (**100 kg Urea + 200kg NPKS +100kg seed/ha**), T: 6= (**100 kg Urea + 200kg NPKS +200kg seed/ha**)**

3.2.2. Number of Spike

The results of analysis of variance indicate that NPKS fertilizers and seed rates application was non- significant effect on number of spike at Debre Markos University research site but was slightly significant at Enereta kebele FTC. At Enereta kebele much number of spikes was counted from the application of 322 kg Urea + 200kg NPKS +200kg seed/ha followed by the application of 300 kg Urea + 100kg NPKS +200kg seed/ha. But the remaining treatments showed statically equal number of spike (Table 2)..

3.2.3. Total above Ground Biomass Yield per Plot

The results of analysis of variance indicate that NPKS fertilizers and seed rates application was highly significant ($p < 0.001$) effect on total above ground biomass yield at both sites. At both sites the maximum total above ground biomass per plot was measured from the application of 322 kg Urea + 200kg NPKS +200kg seed/ha whereas the lowest total above ground biomass was found from use of 100 kg Urea + 200kg NPKS +100kg seed/ha. The remaining treatments gave statically similar amount of total above ground biomass (Table 3). .

Table 3. Evaluation of urea and blended fertilizer and seed rates on total above ground biomass yield and straw yield at selected FTC sites of East Gojam Zone

Treatments	Campus site		Enereta FTC	
	Total Biomass Yield(kg)	Straw Yield(kg)	Total Biomass Yield(kg)	Straw Yield(kg)
1	10.3333 [cd]	6.6933 [ba]	4.7333 [b]	2.9300 [c]
2	13.7333 [a]	8.0900 [a]	7.6333 [a]	4.8267 [a]
3	9.8000 [ed]	5.8933 [b]	2.3667 [c]	1.5533 [d]
4	12.1000 [b]	7.0100 [ba]	5.1667 [b]	3.4700 [bc]
5	8.9000 [e]	6.1400 [ba]	3.3333 [c]	1.7767 [d]
6	11.4667 [cb]	6.9667 [ba]	6.5667 [a]	4.2200 [ab]
LSD (0.05)	1.3431	1.9891	1.2068	1.021
CV	6.828996	16.44579	13.35554	17.93328

Means followed by the same letter in a column are not significantly different at P = 0.05; NS = No significance, CV = Coefficient of variation, LSD = Least significant difference. **T: 1= (**322 kg Urea + 200kg NPKS +100kg seed/ha**), T: 2= (**322 kg Urea + 200kg NPKS +200kg seed/ha**), T: 3= (**300 kg Urea + 100kg NPKS +100kg seed/ha**), T: 4= (**300 kg Urea + 100kg NPKS +200kg seed/ha**), T: 5= (**100 kg Urea + 200kg NPKS +100kg seed/ha**), T: 6= (**100 kg Urea + 200kg NPKS +200kg seed/ha**).**

3.2.4. Straw Yield per Plot

The results of analysis of variance indicate that NPKS fertilizers and seed rates application was slightly significant effect on straw yield at both sites. Application of 322 kg Urea + 200kg NPKS +200kg seed/ha gave the maximum straw yield at both sites (Table 3). Similarly the lowest straw yield was measured by the application of 300 kg Urea + 100kg NPKS +100kg seed/ha at both sites (Table 3).

3.2.5. Number of Fertile Tillers

The results of analysis of variance indicate that NPKS fertilizers and seed rates application was less significant on number of fertile tillers at Campus and Enereta FTC (Table 4). A lot of fertile tillers were counted from the applications of 300 kg Urea + 100kg NPKS +200kg seed/ha at the two sites. Application of 300 kg Urea + 100kg NPKS +100kg seed/ha at Debre Markos University research site gave higher numbers of fertile tillers in the contrary at Enereta kebele FTC it had lower numbers of fertile tillers. The less number of fertile tillers were counted from the use of 100 kg Urea + 200kg NPKS +200kg seed/ha and 322 kg Urea + 200kg NPKS +100kg seed/ha at Debre Markos University research site and Enereta FTC respectively(Table 4). .

Table 4. Evaluation of urea and blended fertilizer and seed rates on number of fertile tillers and grain yield at selected FTC sites of East Gojam Zone

Treatments	**Campus site**		**Enereta FTC**	
	Number of Fertile Tillers	**Grain Yield(kg)**	**Number of Fertile Tillers**	**Grain Yield(kg)**
1	124.33 [ba]	4.2400 [ba]	55.667[bc]	1.8033[abc]
2	101.00 [bc]	3.9067 [ba]	88.000[a]	2.8100[a]
3	127.67 [a]	5.0433 [a]	39.667[c]	0.8133[c]
4	127.33 [a]	4.1900 [ba]	92.333[a]	1.7000[abc]
5	95.00 [c]	3.7600 [b]	74.667 [ab]	1.5567[bc]
6	80.67 [c]	3.5000 [b]	87.000[a]	2.3467 [ab]
LSD (0.05)	24.558	1.2321	19.997	1.2403
CV	12.62578	16.86467	15.08037	37.08603

Means followed by the same letter in a column are not significantly different at P = 0.05; NS = No significance, CV = Coefficient of variation, LSD = Least significant difference. **T: 1= (**322 kg Urea + 200kg NPKS +100kg seed/ha**), T: 2= (**322 kg Urea + 200kg NPKS +200kg seed/ha**), T: 3= (**300 kg Urea + 100kg NPKS +100kg seed/ha**), T: 4= (**300 kg Urea + 100kg NPKS +200kg seed/ha**), T: 5= (**100 kg Urea + 200kg NPKS +100kg seed/ha**), T: 6= (**100 kg Urea + 200kg NPKS +200kg seed/ha**).**

3.2.6. Grain Yield per Plot

The results of analysis of variance indicate that NPKS fertilizers and seed rates application was less significant on grain yield at Debre Markos University research site and Enereta kebele FTC. The highest grain yields were measured by the Application of 300 kg Urea + 100kg NPKS +100kg and of 322 kg Urea + 200kg NPKS +200kg at Debre Markos University research site and at Enereta kebele FTC respectively (Table 4). . The lowest grain yields were measured by the Application of100 kg Urea + 200kg NPKS +200kg seed/ha and by Application o300 kg Urea + 100kg NPKS +100kg seed/ha at Debre Markos University research site and at Enereta kebele FTC respectively. The remaining treatments gave statically similar amount of grain yield(Table 4). .

4. CONCLUSIONS AND RECOMMENDATION

Ethiopia is the second largest producer of wheat in sub-Saharan Africa following South Africa. To meet the food demand and the need of emerging agro-industries in the country, increasing the production and productivity of wheat with improved agronomic practices and appropriate soil management practice is important. Use of the correct type, rate, time and method of application of fertilizers is important for raising production and avoiding damage to the environment. Despite several years of agronomic research on the response of specific food crops to various types of fertilizers, over-generalized and rigid recommendations on their use continue to be made (Gachene and Gathiru, 2003). Such a blanket recommendation does not do justice to the differences in agro-ecology, indigenous soil nutrient supplies and crop specifications (Asefa, 2008). The blanket fertilizer recommendation may be in excess of or less than the optimum requirement for crop growth and development. Therefore, the best types and amounts of fertilizer to use for a particular crop in a given area should be decided.

Use of a given high yielding Wheat genotype accompanied with improved production technology packages like optimum NP fertilizations with optimum planting density could markedly increase productivity per a given hectare. Therefore, taking these problems into account this research was initiated with the objectives of evaluating the effects of applied Urea and NPKS rates with different seed rates and to determine the optimum Urea and NPKS fertilization and the optimum seed rates on wheat crop at selected FTC sites of East Gojam Zone, Ethiopia.

Field experiment comprises of six treatments, i.e. combined application of three rates of urea and NPKS (Package, Innovation and Framers' practice) fertilizer and two seed rates (recommended and farmers practice rates) was laid out in randomized complete block design (RCBD) with three replications.

The results of analysis of variance showed that except the number of spike and number of grains per spike, all other yield and yield attributes were significant affected at both sites. The highest plant height, spike length, total above ground biomass and straw yield were measured by the application of 322 kg Urea + 200kg NPKS +200kg seed/ha at both sites. The maximum number of fertile tillers were counted from the application of 300 kg Urea + 100kg NPKS +200kg seed/ha at both sites. The highest grain yields were measured by the application of 300 kg Urea + 100kg NPKS +100kg and of 322 kg Urea + 200kg NPKS +200kg at Debre Markos University research site and at Enereta kebele FTC respectively.

Finally, the results showed that at Enereta FTC the best performing treatments were 322 kg Urea + 200kg NPKS +200kg seed/ha and 300 kg Urea + 100kg NPKS +200kg. In addition, the results showed that at Debre Markos University research site the best performing treatments were 300 kg Urea + 100kg NPKS +100kg and 300 kg Urea + 100kg NPKS +200kg.

Generally at Enereta kebele FTC, the optimum amount of urea, NPKS and seed rate can be estimated as 300/322 kg Urea, 100kg /200kg NPKS and 200/200 kg seed respectively. At Debre Markos University research site the optimum amount of urea, NPKS and seed rate can be estimated as 300 /300 kg Urea, 100/100kg NPKS and 100/200 kg seed respectively. However, their economic rates of fertilizer and seed applications would have to be assessed to achieve sustainable crop yields.

Unlike to soil of Debre Markos University research site, soils of Enereta kebele FTC was highly depleted so that optimum plant growth and better production can be obtained from higher dose of urea, and NPKS, but adequate soil analysis must be made for both sites in the future. In general, management activities for the crop and these soils; should be practiced, and the strategies for which should be applied according to either the Package or Innovative fertilizer use practice.

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